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ABSTRACT

The implementation of effective science programs in primary schools is of continuing interest and concern for teacher educators. Recent Australian national initiatives have been designed to foster the teaching of science in primary schools. At the provincial level in Queensland, decisions concerning the planning and introduction of a new primary science syllabus are still pending. As part of the Australian Academy of Science's approach to creating an awareness of the national curriculum project called "Primary Investigations," a project team tried out a series of satellite broadcasts of lessons related to two units of the curriculum for grades 3 and 4. The curriculum development project included a focused inservice component for the respective classroom teachers, also conducted by satellite. This paper reports the involvement of a grade 4 teacher in the project and analyzes her professional growth in the areas of self-efficacy and motivation. Already an experienced and confident teacher, the subject showed no quantitative changes in self-efficacy; however, her pedagogical content knowledge and confidence to teach science in the concept areas covered by the broadcast were enhanced. Changes in the teacher's views about the cooperative learning strategies espoused by "Primary Investigations" were also evident. All the results suggest implications for the design of inservice programs for primary science teachers. (Contains 41 references.) (Author/SWC)

# The Professional Growth of a Primary School Teacher Engaged in an Innovative Primary Science Trial Curriculum Development Project Utilising Satellite Broadcasting.



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Paper presented at the Annual Conference of the Australasian Science Education Research Association, Canberra July 1996.

# The Professional Growth of a Primary School Teacher Engaged in an Innovative Primary Science Trial Curriculum Development Project Utilising Satellite Broadcasting.

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*Abstract*

The implementation of effective science programmes in primary schools is of continuing interest and concern for teacher educators. Recent national initiatives such as Science - A Curriculum Profile for Australian Schools and the curriculum project *Primary Investigations - The Science Program for Primary Schools*, sponsored by the Australian Academy of Science (AAS), were designed to foster the teaching of science in primary schools. In the Queensland context, decisions concerning the planning and introduction of a new primary science syllabus are still pending. As part of the Academy of Science's approach to creating an awareness of *Primary Investigations*, a project team trialled a series of satellite broadcasts of lessons related to two units of the curriculum for grade 3 and 4 children in a number of participating schools. The curriculum development project included a focused inservice component for the respective classroom teachers, also conducted by satellite. This paper reports the involvement of a grade 4 teacher in the project and analyses her professional growth from the theoretical bases of personal science teaching efficacy and related attitudes, and motivation to teach science. Already an experienced and confident teacher, no quantitative changes in science teaching self-efficacy were detected, however, her pedagogical content knowledge and confidence to teach science in the concept areas of matter and energy were enhanced. Changes in the teacher's views about the co-operative learning strategies espoused by *Primary Investigations* were also evident. Implications for the design of inservice programmes for primary science teachers are discussed in the paper.

This study aimed to examine changes in a teacher's attitudes, sense of science teaching self-efficacy and science teaching practice as a consequence of involvement in a primary science curriculum development project delivered by interactive television. Teachers' prior beliefs about education are important elements in any change process. In particular, if student performance improves teachers will attribute these changes to specific events. If such events include credible peer teaching, collegial support and support specifically targeted at them, resistance to change should be minimised. The six televised children's broadcasts employed in this study were designed to provide vicarious experiences in the teaching of science for primary teachers and assumed no particular skills or experiences on their part. The broadcasts were linked to the recently produced primary science package, *Primary Investigations* (Australian Academy of Science, 1994). There was an expectation that teachers would follow-up each broadcast by implementing lessons of their own from *Primary Investigations*. The project included two additional broadcasts directed at teachers, which outlined essential features of the *Primary Investigations* curriculum package.

Monitoring of changes in attitudes and self-efficacy was undertaken by administering a questionnaire to all teachers in the school and through an interview of the teacher prior to the initial television broadcast. In addition, the attitudes of children towards science prior to the project were measured to provide some indication as to whether emotive changes were occurring in the classroom that may have impacted on the teacher. Anecdotal and incidental events associated with the project and involvement of the teacher and children were monitored during each broadcast. Finally, the status of attitudes and self-efficacy of the teacher were re-examined at the conclusion of the intervention.

Science education is in an era of reform but if any innovation is to become integral to a school's development and curriculum plan, the whole school should participate actively in a cycle of initiation, implementation and institutionalisation which extends over several years. Each phase is critical to the long-term success of any new initiative because what happens during one phase of implementation influences what happens during subsequent phases. Establishing an impetus for change, the initiation phase is especially crucial. It is during this phase that beliefs, attitudes and a sense of self efficacy must be addressed. A community in which self efficacy is raised should impact strongly on a will to implement change (Berman, McLaughlin, Bass, Pauly, & Zellman, 1977; Fullan, 1993). This study focuses particularly on the potential of an inservice project to impact on self-efficacy and is the first stage of a larger study designed to monitor the full-scale introduction of *Primary Investigations* into a number of Queensland schools.

## *Background*

The state of the teaching of science in primary schools is of constant concern. Arguments supporting the need for science education have been based on the desire to develop in children the skills and knowledge required to empower them in a technological society (Fensham, 1994). There is, however, a low level of science teaching activity in schools in Australia noted in particular by the DEET Report (Department Education Training and Employment, 1989) which linked the poor state of teaching with inadequate preservice and inservice preparation in the science disciplines. The pragmatics of preparing specialist primary teachers with undergraduate degrees in science are inconceivable. Furthermore, a focus entirely on content knowledge reinforces a notion that science is a body of facts to be learned and that the teacher is the fountain of that knowledge. Such a belief is contrary to our current insights into how children come to an understanding of science that goes beyond rote memory. It is these issues that may play a more important role in the motivation of teachers to engage in worthwhile science teaching. Indeed, at the core of anxiety about teaching science by many preservice teachers is the perception that science is a body of irrelevant facts and has no personal relevance for most people (Watters & Ginns, 1995). However, preservice science subjects implemented with a focus on science as a meaningful and relevant social endeavour, and which espouse constructivist principles, can impact positively on students' science teaching self-efficacy (Watters, Ginns, Asoko, & Enochs, 1995).

However, among many practising teachers there is also a lack of confidence in their own knowledge of science (Kahle, Anderson & Damjanovic, 1991; Manning, Esler & Baird, 1982; Mechling, Stedman & Donnellan, 1982) and furthermore, a low level of science teaching self-efficacy grounded in attitudes and beliefs developed through their own experiences of learning science (deLaat & Watters, 1995). Hence, there is a critical need to identify and establish the significance of factors, other than prior conceptual knowledge, which contribute to the implementation of science programmes in primary schools.

Two contributing factors, that we believe require thorough investigation, are derived from self efficacy theory (Bandura, 1977; 1986). They are, firstly, the personal beliefs of primary teachers about their ability to teach science and, secondly their beliefs about the effectiveness of good science teaching to impact on children's learning. Bandura's self efficacy model has provided the most significant insights into the general behaviour of teachers (Ashton, Webb & Doda, 1983; Ashton & Webb, 1986; Dembo & Gibson, 1985; Greenwood, Olejnik & Parkay, 1990). Teacher efficacy is a construct derived from Bandura's (1977) theory of self efficacy. He suggested that behaviour is based on two factors, firstly, people develop a generalised expectancy about action-outcome contingencies through life experiences (*outcome expectancy*) and, secondly they develop a more personal belief about their own ability to cope, or *self efficacy*. In cases where both efficacy and outcome expectancies vary, behaviour can be predicted by considering both factors. For example, Bandura (1977) hypothesized that a person rating high on *both* factors would behave in an assured, confident manner.

An initial study into primary teachers' self efficacy beliefs in the domain specific area of science education, undertaken in an American setting by Riggs and Enochs (1990), extended the large number of studies into teachers' attitudes to science and science teaching and provided a theoretical framework for research into the complementary relationships between self efficacy, attitudes and practice. Attitudes of teachers towards science and science education have been reviewed by Morrisey (1981), Willson (1983) and Schibeci (1984). Schibeci identified complex relationships apparent between variables such as sex, home background, specific programmes designed to change attitudes, discipline and age. Recently Koballa (1988) and Shrigley, Koballa, and Simpson (1988) focused on three aspects of attitude, namely, that attitudes are relatively stable, that attitudes are learned and that attitudes are related to behaviour. Thus if attitudes are influenced by beliefs then research on personal and teaching efficacy will be important for developing an understanding of the relationship between attitude to science and the teaching of science.

Therefore, we extend the work of Riggs and Enochs (1990) and our own study of changes in preservice and practising teachers' sense of efficacy in teaching science (Ginns, Watters, Tulip & Lucas, 1995; Ginns & Watters, 1994, Ginns & Watters, 1996) by examining the effect of a curriculum development project on a teachers' sense of science teaching self-efficacy. Berman, McLaughlin, Bass, Pauly, & Zellman (1977) found that the most important characteristic determining the effectiveness of change-agent projects was the teacher's sense of self efficacy. In science education, Ellis (1995) has reported the significant enhancement in personal science teaching self efficacy among teachers participating in a collaborative inservice programme in Colorado. Given Fullan's (1993) contention that the engine of deep change in the education system is the individual teacher, it is clear that continuing research needs to be done into exploring teachers' self efficacy and practice in school systems as a result of inservice professional development projects. Meaningful change is only likely to be successful if professional development can impact at the organisational level through collectively enhancing self-efficacy.

The major focus in this study was to determine those contextual factors that may contribute to changes in the level of self efficacy of primary teachers engaged in an inservice project. This was accomplished by studying the ongoing practice and behaviours of one teacher during a period of probable intensive professional and personal self-analysis initiated by involvement in an intervention designed, in part, to provide models of exemplary practice. Our hypothesis is that the extent to which teachers feel that they are able to successfully implement a worthwhile science programme may depend on their sense of self efficacy, that is, their personal beliefs about their ability to teach science and their ability to produce positive outcomes in science for children.

Bandura (1977) has argued that self-efficacy is changed by successful personal experiences, vicarious experiences or by persuasion. Inservice programmes usually involve the least effective form of change, persuasion. The intervention described in this study was also analysed for the presence of highlights which could be described as promoting successful involvement and learning by the children, thereby presenting appropriate vicarious experiences for the teacher, and encouraging successful implementation of lessons by the teacher.

## The Study

### *Experimental Design*

The research design adopted was a case study approach (Erickson, 1986; Miles & Huberman, 1994) involving observation and recording of a teacher's behaviours in teaching science to two Grade 4 classes in a school participating voluntarily in the trial curriculum development project based on the Australian Academy of Science's new science curriculum *Primary Investigations.*

### *The Subject*

The subject of this study was Anna. She has taught at the participating school for 19 out of her 26 years of teaching. Both Grade 4 classes are normally taught science by Anna, however, she has not regularly taught science above Grade 5 level. She is a teacher described by her principal as a traditionalist.

### *Context—School and Principal*

The school was a Catholic Parish school comprising approximately 400 children located in a middle-low socio-economic area of metropolitan Brisbane. The school had in the previous year installed a satellite communications receiving dish and had participated in a series of satellite delivered lessons in Japanese. The school saw itself as a leader in the use of advanced technology in both instruction for children and inservicing for teaching. The technology was familiar to the teachers and there appeared little concern with the technological aspects of this initiative. The principal was visionary in providing leadership in this mode of education and was well supported in the initiative by his staff and community.

### *Data Collection*

Quantitative and qualitative data were collected in a number of ways. Immediately prior to the implementation of the initiative, all teachers in the school were surveyed to establish their level of science teaching self efficacy. A number of semi-structured interviews were conducted with the teacher to probe her beliefs, experiences and theories-in-action. At the completion of the curriculum development project and at the conclusion of the teaching year, follow up self efficacy tests and interviews were undertaken. Classroom observations were made of all science lessons and broadcasts for the duration of the project. The details of these measures are described as follows.

(a) Standardised psychometric tests were used for:

- a pretest measure of personal and science teaching self-efficacy of all teachers in the school;
- pretest and posttest measures of the personal and science teaching self-efficacy of the teacher;
- identification of the teaching subject preferences of all teachers in the school prior to the intervention;
- identification of the teaching subject preferences of the teacher prior to the intervention and after the intervention;
- observation of the level of concern of the teacher at two stages of the implementation of the project;
- surveying children's attitudes to science prior to and at the completion of the intervention.

(b) Semi-structured interviews with the teacher were used to:

- explore the teacher's personal reflections on her own schooling, tacit or prior knowledge, and other contextual factors in an initial interview.
- obtain the teacher's perceptions of the important structural elements of her science programme;

- obtain her personal perceptions of the effectiveness of the interactive television broadcasts and subsequent implementation of lessons from *Primary Investigations*.

(c) Additional semi-structured interviews were conducted to:

- obtain the perspectives of the school Principal on the project;
- obtain the perspectives of the teacher's Grade 4 teaching colleague on the project;
- probe the impact of the intervention and subsequent follow-up activities on the attitudes of a selected group of children. Children in bands of high and low interest and attitude to science were chosen for ongoing interviews. and their responses were analysed within the adopted theoretical framework to develop an understanding of the participants actions (Erickson, 1986).

(d) Observations were made of:

- student-teacher interactions occurring during the televised children's broadcasts;
- the implementation of the follow-on lessons from *Primary Investigations*;
- the interactions during group work of the children selected for interviews.

All interactions during the children's broadcasts were video and audio taped. Video tapes were made of the follow-on lessons and interactions between children during several lessons were audio taped. Observations of classroom practice were also recorded in field notes and member-checked with the teacher after construction of a profile of action (Guba & Lincoln, 1993).

### *Instruments*

The following psychometric tests were used:

(a) Personal Science Teaching Efficacy (PSTE) and Science Teaching Outcome Expectancy (STOE) scores for the teacher were obtained using the Science Teaching Efficacy Belief Instrument (STEBI-A) which contains two standardised scales designed to measure these constructs (Riggs & Enochs, 1990). The preservice version of this instrument has been validated in the Australian context with preservice primary teacher students (Ginns, Watters, Tulip & Lucas, 1995).

(b) The teacher's subject preferences were identified using an established test, the Subject Preference Inventory (SPI) instrument devised by Markle (1978). This instrument establishes primary teachers' preference for teaching various subjects and has been used by Riggs and Enochs (1990) in their work on developing a science teaching efficacy belief instrument. The instrument has been adapted for use in the Australian context (deLaat & Watters, 1995).

(c) The level of concern about how the innovation affected the teacher and her concerns about implementing change were monitored using the Stages of Concern Questionnaire (SoCQ) (Hall, George, & Rutherford, 1977). The instrument consists of seven measures of seven stages of concern about innovation and change: awareness, information, personal, management, consequence, collaboration and refocusing.

(d) Children's attitudes to science were surveyed using a modified version of TOSRA (Fraser, 1981) that only included 21 questions assessing four scales: adoption of scientific attitudes, enjoyment of science, attitude to scientific inquiry and leisure interest in science.

The timeline of the study and related events are depicted in Table 1.

Table 1

*Timeline of Study and Related Events*

| Week | Event |
|---|---|
| 1 | Attitudes test children<br>STEBI-A teachers<br>SPI teacher<br>SoCQ teacher |
| 2 | Interview with subject<br>Interview with partner teacher<br>Interview with Principal<br>*Simply Science - Teacher Broadcast #1*<br>Group interview with subject and partner teacher (after Teacher Broadcast #1)<br>*Simply Science - Children's Broadcast #1* |
| 3 | Implemented Primary Investigations lesson #1 [Straw Towers]<br>*Simply Science - Children's Broadcast #2* |
| 4 | Implemented Primary Investigations lesson #2 [Patterns of Strength]<br>Interview with selected children (group)<br>*Simply Science - Children's Broadcast #3* |
| 5 | Implemented Primary Investigations lesson #3 [Finding Strong Structures]<br>*Simply Science - Teacher Broadcast #2*<br>*Simply Science - Children's Broadcast #4* |
| 6 | Implemented Primary Investigations lesson #4 [Windy Weather]<br>*Simply Science - Children's Broadcast #5* |
| 7 | Implemented Primary Investigations lesson #5 [Weather Watch]<br>Interview with selected children (individual)<br>*Simply Science - Children's Broadcast #6*<br>Interview with Anna |
| 8 | Implemented Primary Investigations lesson #6 [Weather Patterns]<br>Interview with Principal<br>Attitudes test children<br>STEBI-A Teachers<br>SPI Anna<br>SoCQ Anna |

## The intervention

Direct Broadcast Network Pty Ltd in association with the Australian Academy of Science trialled a televised curriculum development project for some 33 primary schools nation-wide in 1995. The project, titled *Simply Science*, was comprised of six weekly broadcasts for children, and two broadcasts for teachers, designed to foster and support the teaching of science in the classroom. The children's broadcasts, each of twenty five minutes duration, presented topics extracted from the Academy's *Primary Investigations* curriculum package. *Primary Investigations* is an integrated science, technology and environmental studies curriculum that implements Bybee's (1993) sequence of lessons that attempt to engage, explore, explain, elaborate and evaluate. The curriculum is constructivist in philosophy and implements a co-operative learning mode built about themes which, for example, in Grade 4 emphasise Patterns and Predictions.

The broadcasts for Grade 3/4 children specifically addressed a concept that was followed up by implementing a *Primary Investigations* activity. The concepts superimposed on the theme of Patterns and Predictions concerned the properties of matter, explicitly solids in terms of structure, strength and function, liquids in terms of fluidity, and gases in terms of compressibility and pressure. The format of presentation involved two studio-based teachers and a host leading discussions, implementing activities and reviewing past broadcasts. The script was supported by video clips of everyday examples of concepts and processes which were used by the studio-teachers to link the content and real world applications. Interactive engagement with children was achieved through telephone communication with selected schools during each broadcast. The reality of production resulted in a somewhat diluted approach which deviated from the stated intents of the curriculum package. The project nevertheless, attempted to help teachers set up autonomous learning environments with a focus on negotiation of meaning through co-operative learning. The two broadcasts directed at participating teachers emphasised the constructivist philosophy of *Primary Investigations* in the first and the co-operative learning approach in the second.

Prior to the commencement of the project the school was supplied with a small booklet in which the purpose of *Simply Science* was explained, background reading for each broadcast provided and a synopsis of each follow up activity given. Group work was emphasised and instructions given to reinforce the co-operative model used in the Primary Investigations curriculum, although no conceptual foundation for the model was presented. Teachers were encouraged to integrate the science learning experiences and to allow students to explore their own ideas, make meaningful interpretations and to make links to their own personal worlds. Overall, the project was seen to be an incentive for teachers to implement the new curriculum package and its philosophy and the children's broadcasts were designed to provide them with a starting point for the investigations contained within the relevant *Primary Investigations* books. Consequently, as a more child-centred approach, the project was expected to impact on children's attitudes to science and conceptual change by giving them the opportunity to engage in meaningful learning and to provide inservice professional development for participating teachers.

## Analytical Framework

The *Primary Investigations* curriculum package is based on assumptions about children's learning that are consistent with the philosophies and implicit structures that underpin a constructivist learning environment. By adopting a cognitive apprenticeship model it provides teachers with an opportunity to develop in classrooms a community of learners (Collins, Brown & Newman, 1989). As a package it aims to support teachers with detailed instructions, background knowledge and directs the teacher to:

> *consider yourself an instructional leader and guide, and allow students to bring their own experiences to their learning. Your role is to question, probe, clarify, monitor and assist and otherwise encourage students to progress.* (Australian Academy of Science, p. x).

Consistent with this approach, teaching episodes, events and interactions were analysed using a framework that drew upon the work of Taylor, Fraser and White (1994) and Kruger and Summers (1993).

Taylor, Fraser and White (1994) examined the socio-cultural forces shaping the high school science classroom from a critical theory perspective. Factors identified as important elements of such an environment include: (a) making science seem personally relevant to the outside world; (b) engaging students in reflective negotiations with each other; (c) instructors inviting students to share control of the design, management, and evaluation of their learning; (d) students being empowered to express critical concern about the quality of teaching and learning activities; and (e) students experiencing the uncertain nature of scientific knowledge.

Drawing on the work of Neale, Smith and Johnson (1990), Kruger and Summers (1993) examined the teaching and learning of science concepts in primary classrooms from a teacher's implementation perspective. They characterised effective teaching of primary science in terms of a framework involving: (a) conceptual accuracy, (b) conceptual emphasis, (c) extent of use of appropriate representations such as analogies, examples or metaphors and any linkage of these to children's interests and everyday experiences, (d) appropriate task or activities, (e) the use made of children's ideas, (f) science teaching strategies, (g) flexibility, or the teacher's ability to respond, (g) appropriate differentiation and clarity of progression.

## Findings

### *Anna's story*

Anna was interviewed a week before the first broadcast of *Simply Science*. The open-ended interview probed a range of topics that included her own experience in learning science, her philosophies and strategies for teaching science and her expectations for the forthcoming telecast. She was informally interviewed after each subsequent television broadcast and following the lessons that were implemented in the classroom. A final interview was undertaken after the completion of the project. Further contact was made at the commencement of the following year when the School decided to implement the *Primary Investigations* curriculum package on a school basis.

Anna attended primary school as a child in Brisbane from which time she expressed vague recollections of doing something in science around about Year 6 or Year 7 but not much. She went to secondary school where she did not take any science courses. Her two years at teachers college included some science which she found "most interesting because it was all new". To her science was interesting as she has carried that enthusiasm with her for the twenty years of teaching. However, she remains apprehensive about teaching science above Year 4 level.

In teaching science her focus is on the major concept area of Life and she relies on the Queensland Science Sourcebook which for ideas. On average she allocates about an hour per week on science with the added responsibility for teaching both of the Year 4 classes in the school. She appears to enjoy teaching science and believes it is very important but she makes no attempt to integrate it with other areas of the curriculum. She does not attend science inservice programmes or conferences. A big constraint on her teaching science is the lack of resources: "If I look in the Sourcebook and there's something I think 'We haven't got all that, where am I going to find these materials?' I'll avoid that one. Resources is a really big factor. I'd say number one." She acknowledges her lack of content knowledge and weak background in science but she does not see this as a major handicap. Her attitude to children who ask questions that she does not know the answer to is "Let's find out. Let's look it up. Let's find someone who knows who can tell us." She almost sees this as an advantage because it makes the children go and find the information and to think about it.

The children in her class warm to her and are comfortable, if not slightly exasperated, with the environment she and her teaching colleague have established:

> *what they say is **maybe**, and a year later they go **maybe** and you ask them again and they go **maybe** and they never do it* : Jennifer

She was unaware of modern science teaching theories and terms such as constructivism were, at the beginning of the study, unknown to her. However, she did, in practice, recognise that children do contribute their own knowledge to the learning environment: "They contribute quite a bit from their experiences they share with us and that enhances the lesson I would say. ... I am always really listening to what they say. They have had lots of experiences in different things and they will give me information and I'll say 'I didn't know that. I've learnt something today'."

Anna's pretest scores on the two scales of STEBI-A are indicative of a high level of science teaching self-efficacy (Table 2).

Table 2

*Changes in Anna's self-efficacy scores*

| Scale | Anna's pretest scores | Anna's post test scores | School mean | StDev |
|---|---|---|---|---|
| Science teaching self efficacy PSTE | 50 | 46 | 44.15 | 7.83 |
| Science teaching outcome expectancy STOE | 41 | 45 | 38.77 | 5.93 |

### *The Experience*

Anna was somewhat unprepared for the project having had little forewarning about the broadcasts and little opportunity to read the *Primary Investigations* resource materials. Nevertheless, she was looking forward to it as a personal learning experience and one that she believed that children would enjoy. She anticipated seeing actual lessons being taught and hence from such a vicarious experience she hoped to learn new procedures and strategies.

From the first teachers' broadcast, Anna understood that the overall project was aimed at developing curiosity and setting up situations in which children could be engaged in activities that allowed extensive observation and prediction. Her colleague Kathy, a younger teacher and a recent graduate, described the broadcast as focusing on the way she believed science should be taught with an emphasis on children trying to find out for themselves and then attempting to clarify reasons for the way things are. However Kathy, who scored lower than the school mean on the Personal Science Teaching Efficacy scale (Table 2), was herself uncomfortable in teaching science despite having a strong high school background in the discipline.

Neither teacher seemed at this stage to express major concern or apprehension about the intended project. The greatest concern lie in the pragmatics of implementing the planned lessons, for example, the number of straws needed, the right cardboard, the extent to which some of this material had been taught, relationship with the school programme, the distribution of books and other managerial concerns. These concerns were supported by the interpretation of the SoCQ survey described later.

The second teacher broadcast was seen by Anna after three lessons had been taught. The theme of this broadcast was on co-operative learning, a conceptualisation of which was essentially ignored to this point. Although co-operative learning is emphasised in the *Primary Investigations* teacher's books, the rationale and purpose is not explicit. Hence, the implementation of co-operative learning became strategic and directed, but not conceptual (Johnson & Johnson, 1995).

### *Review of Lessons Taught by Anna*

On analysing the first lesson [Straw Towers], it appeared that there were two main things happening. One was that the class and the teachers were coming to terms with the co-operative group work and secondly, the children were finding out their roles and learning to accept that the co-operative group work approach was going to be more or less a regular way of working in science. Most children worked in groups whereas several maintained an individualistic approach. There was no consideration of the cognitive role of group work as being a possible purpose for working in this structure. Anna's reflection on the class focused on the observation that the children were enjoying the activity and that there appeared to be a commitment to work productivity.

> *I'm happy I think they all enjoyed it and they worked hard and they've come with something to present to the whole class, I'm pleased with the way it went. Some children could perhaps have contributed more, that's basically the nature of the beast I think. Some children are very enthused.*

The interpretation of co-operation was interesting in that it was seen to be effective because there was a purposeful allocation of tasks by the children. Co-operation was about helping and sharing in the physical and infrastructure support and "taking turns" or doing tasks that individuals prefer. The group dynamics was also an important consideration:

> *A lot depends on who I put them with too, I had a group with John, Curtis and Ian and that group there and they seemed to all get on really well. There the sort of kids ... no matter where you put them and wherever I put Jake he will argue, and after a couple of weeks he'd suggest different grouping...*

Attempts were made to make the science personally relevant for the children to the outside world.

In lesson two [Patterns of Strength] the familiarisation of the teacher and children with co-operative group work continued. This was reflected in the gradually increasing involvement of the teacher in the process and the active engagement of the children in the individual construction work required as part of the lesson plan. Individual children were not challenged by having to justify or share reasons why he/she decided to construct a particular pattern to strengthen an object.

Approximately 15 minutes of lesson three [Finding Strong Structures] were spent outside looking at structural features of buildings in the school. The children examined relevant photographs in the *Student's Book* and the teacher was actively engaged with the groups requiring them to observe more closely, however, little scaffolding was evident. Instructions were directed towards keeping children 'on task'. Children appeared to enjoy doing the activity, although they were not directly challenged as to why various patterns of strength are needed so that structures can, for example, support a given load without collapsing or bending and thus be safe to use.

In lesson four [Windy Weather] the teacher established the theme of the unit by focusing on observation of the weather and the need to collect data over a certain period of time. Several children brought forward interesting ideas, particularly one about air to lift a plane, but these were not fully incorporated into the lesson by the teacher. Some debate between the children was encouraged but no in-depth justifications for statements made by the children were actively sought. Higher level engagement with the children occurred during the construction of the wind speed meters. An outdoor component of the lesson involved using the instrument and measuring the wind speed. The lesson did actively engage the children with the idea of weather and helped them explore some ways of investigating weather.

Although the teacher very effectively set the theme of lesson five [Weather Watch] both indoor and outdoor segments of the lesson required a lot of time to organise the groups, provide instructions on how to fill in the record sheet, and how to report relevant readings because of the requirement to conduct weather observations over 5 consecutive days. The organisational aspects of the extended lesson negated any immediate use of the data that children were going to collect, hence the questions tended not to be open-ended. Similarly, no attention could be paid to using the collected data to explain the type of weather that was being experienced at the time.

In lesson six [Weather Patterns] much discussion was generated by the weather satellite photographs supplied in *Primary Investigations Student Book*. The teacher generated this discussion by using a model of a globe and ball to show a weather satellite above the earth. The model appealed to the children. Anna demonstrated evidence of accepting children's views of information contained in the photographs but there was a tendency to steer them to a 'correct' interpretation of the information. A shift towards listening more carefully to the children's responses and getting children to respond to each other's comments and suggestions was clearly evident. Children's alternative views were sought and students were challenged to justify their predictions and/or assertions. Interactions with children in group work focused on assisting and guiding the children and getting them to think more about the task in hand.

*Anna's perceptions of* Simply Science *and* Primary Investigations

Anna's attitude to co-operative group work had changed by the end of the project. Her early attention was drawn to the physical sharing of labour and social adjustments needed to work co-operatively. By the end of the project an emphasis on the sharing of ideas had emerged. She thought that through discussion everybody's ideas were able to be expressed and that children could listen to each other's opinions and to make decisions on the basis of negotiation. It was important for children to be able to relate to other people's opinions.

> *I think co-operation is a big thing in the whole programme. If you haven't got co-operation, the whole thing falls to bits. Certainly some kids are more co-operative than others of course, some work extremely well and always will. I think it's helped them to respect other people's opinions and not everybody, it doesn't matter who's right and who's wrong, nobody has to be wrong in this do they, how they do it.*

Anna thought that the important feature of the broadcast session from the children's point of view was when they were involved interactively in the programme. From her point of view just watching the children working in their groups in the follow-up lessons in which they were discussing and problem solving was important and personally rewarding. The value of the broadcasts were debatable. Anna saw parts of each children's broadcast as being "interesting and some less so". She believed that the children also found some parts interesting and they tuned out on others:

> *I've only got to watch them watching it and you can see those, when it all goes, and suddenly something came on and they all were looking and the attention waned again.*

However, the visual impact of a number of events was powerful and was important to facilitate learning. In Anna's view the most helpful part of the project was that the broadcasts showed on several occasions children working. This, Anna commented, was useful for both her as a model for how some activities could be used, and for the children as a credible model they could relate to. The children were motivated when they saw other children but become less interested when the presenters were featured. The opportunity to watch other teachers in action was a strong component of Anna's evaluation:

> *I'm always interested looking at other teachers working with children and how they're setting up their lesson and how children work in groups. I could do that, that's a good idea, say from my point of view yes I think that (feature of the broadcast) is important.*

However, she qualified her support for some of the visual elements of the broadcasts by stating:

*They can look at TV all day and look at people bursting balloons and making straw towers and doing this and that, but they can do it themselves. So (it's) the actual lesson that they're involved in. I think the kids working on things themselves in their groups, hands on looking at things, observing, going out here and looking at the wind and the clouds and being involved to me is major, and the TV thing is important too, but without that we could probably still do these lessons anyway.*

When asked about the usefulness of *Primary Investigations* for those who do not teach science, Anna expressed her support indicating that she saw the package as being very supportive and had the potential to change teachers' attitudes towards teaching science:

*... they'd feel better about teaching science, I really do, because we've got the guidelines, we've got the book there and it's all set out and it's very helpful to me because if I had to create all these lessons myself, there's no way I would have even thought of half of that. I have to get everything out of books, and I like it when it's all set out, but the people who said I hate teaching science and they avoid it like mad, do anything but, if they had this programme they could all do it because it's all there and I'm not no whizz person at science as you know, I'm learning a lot of these things as I go along. I really am.*

Clearly she was impressed with the range of activities and the visual impact of these activities. Seeing and being able to duplicate or replicate these was important.

*the kids have to be involved and do the things, like the balloons and the table, which I want to do with these kids, we really need to do that, and I'm going to do that.*

The children's perceptions of the broadcasts and follow-up lessons were gained during and after the programme by interview. Changes in attitudes were also monitored by use of the modified TOSRA instrument.

After lesson two a discussion with a group of twelve children was undertaken by the researchers. The discussion ranged over a number of issues in order to get some insight into the impact of the broadcast and the subsequent lessons. To begin with, science teaching was not a high priority area within the curriculum. What was done was seen to be useful. Most said they had good recollections of previous science lessons they had done that year with Anna and some even commented they had applied knowledge from a lesson on electric circuits in an out-of-class situation. The consensus was that the broadcasts were interesting in part because "it did not need the teacher to explain". This assertion probably reflected some frustration among the children who frequently heard Anna admit that she could not explain specifics. A dissenter in the group, Nathan, found the programme not interesting and not challenging. He frequently expressed very negative comments about science and was more interested in exploring dissections of animals, an image he had constructed of high school science. The children were not drawn on the details of the lesson.

The twelve children were interviewed individually after the series of broadcasts and follow-up lessons and probed with a range of questions that explored their perceptions of what learning had occurred during the six weeks. In particular the questions addressed the constructs identified as components of a constructivist learning environment for example, what their understanding of the nature of science was, the extent that they felt more engaged in learning, their autonomy, and feelings that their own ideas were valued and their acknowledgement of other's ideas. In addition, aspects of the television programme were also explored. The responses from the children universally indicated that the combined television, primary investigations project was interesting and enjoyable. All children were able to articulate a particular episode, activity or concept that had made a significant impact on them. These included strategies for building strong towers, the compressibility of air, understanding how to read weather charts and change in properties of water. The value they saw was particularly in being able to see demonstrations, or examples, and then following that experience up with an in-class activity.

Group work was well accepted. Children liked sharing ideas and having their ideas listened to in small groups. The requirement for less book work and writing was mentioned by several. The children did not, however, feel much in control of what was happening in the class. The teacher orchestrated, directed and managed activities with little consultation with the children. Few were prepared to speak up and challenge strategies or content. Most children saw science in the traditional sense of being a way of understanding and controlling the world. The technological focus was strong with an emphasis on inventing, constructing and physical manipulations. The relevance of some of the experiences had not been identified by the children. For example, one child wanted to become a teacher and thought science would be important because she would have to teach it but not use it in everyday living.

The modified TOSRA instrument gave measures on four scales: *adoption of scientific attitudes*, *enjoyment of science lessons*, *attitude to scientific inquiry* and *interest in science*. At the commencement of the study, girls showed a statistically significant higher level of adoption of scientific attitudes than boys ($F$ 4.2, $df$ 1,42, $p = 0.04$). Differences on other scales was non-significant. At the conclusion of the study, girls had further improved in their adoption of scientific attitudes ($F$ 4.61, $df$ 35,1, $p = 0.04$) with no change for boys. Statistically there was also a significant decrease in boys leisure interest in science ($F$ 4.8, $df$ 36,1, $p = .03$). There were no changes of significance in any of the other scales for either sex.

## Analysis of Findings and Discussion

An analysis of the individual items of the SoCQ revealed that Anna knew little about the project but was keen to find about better ways of teaching science. The pattern exhibited in Figure 1 shows a clear change in her concern about certain aspects of the project. The interview data supported this interpretation and particularly indicated that she had no concern with the proposed full implementation of *Primary Investigations*. An interpretation of the impact on her personally suggested that she was at the end of the project less concerned about the changes to herself as a teacher but there was some concern about the extra energy and time commitments required. The project has raised an awareness in the sense of wanting to engage in discussion about using the programme and be more involved in implementing the programme but she still expresses concern about resourcing. Concerns about management of such a programme were initially low and remained essentially the same except for the issue of organisation of time each day. One of the more obvious changes that emerged during the study was an increased concern with the impact on the students and her concerns about the evaluation of the effect of *Primary Investigations* on the students increased. She wanted to improve communication and discussion of the programme with her colleagues, however, when asked directly about the preparedness to take on a leadership role in developing the programme she was more reticent. Given the limited scope of the project and her familiarity with the whole programme it is not surprising that she has not changed significantly in her desire to revise or enhance the innovation. The television broadcast would have not provided her with sufficient guidance to be prepared to become more innovative or flexible in her use of *Primary Investigations*. This conclusion is supported by an analysis of the implemented lessons for teacher's flexibility based on the Kruger and Summers (1993) framework.

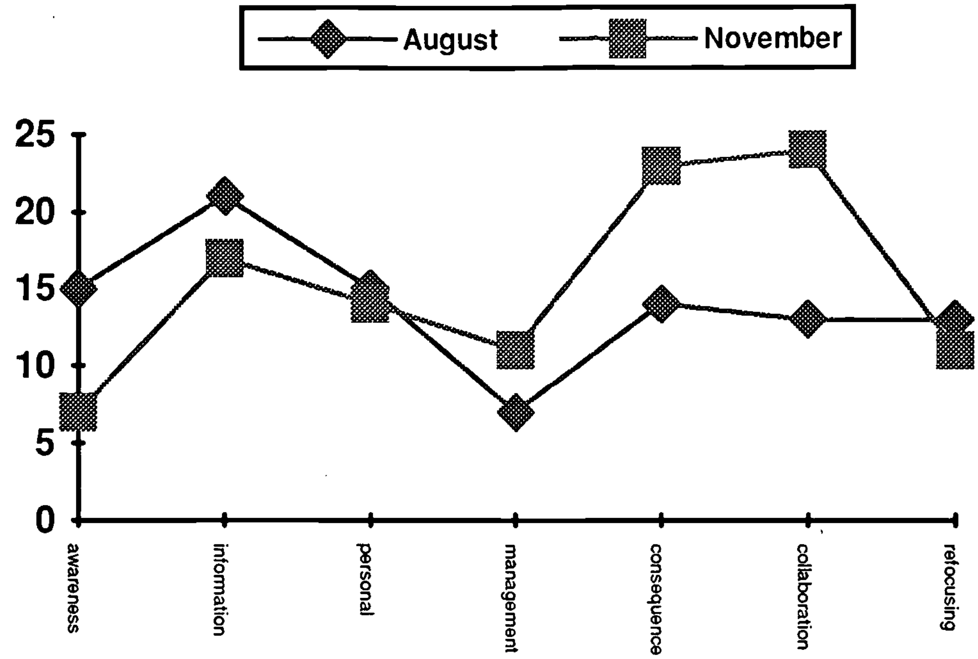


*Figure 1* Stages of concern

The profile that Anna reveals is one of a confident teacher of science who prefers to teach mathematics and science over the humanities and social studies. Although she does not have a strong content background in science, she values the teaching of science for children as a important area of knowledge. She also appears to approach the teaching of the subject in a fashion that recognises children's interests and background experiences but at the same time tends to adopt more teacher-centred pedagogical strategies that are dependent on external resources. The environment is conducive to children expressing their ideas and engaging in discussion which mostly is between teacher and student. Her science teaching self-efficacy is above average reflecting her own perception of success over many years in teaching science, her interest in science and her tacit knowledge of science. The enthusiasm towards science, generated from early days at college is noteworthy. This enthusiasm contrasts with Kathy, her teaching colleague who despite a substantial background in high school science, which she did not enjoy, avoided teaching science and expressed apprehension about the prospect of having to teach science. Her science teaching self-efficacy (PSTE) was 15 points lower than Anna's.

Influencing the learning environment that she establishes in her classroom are elements of those factors considered important for constructivist teaching by Taylor *et al.* (1994). She explicitly draws on children's experiences within the local community and surroundings in her discussions. The significance of lesson material is made known to the children both for their own personal sense of empowerment and as a grounding for further study of science. She attempts to address attitudes by interesting anecdotal stories and a demeanour that conveys science as an interesting and "fun" endeavour. She is willing to listen to children who express critical concern about the events of the classroom but tends not to respond substantively. Indeed, she appears to encourage an environment where there is open discussion of the curriculum and people's feelings. The conceptual emphasis, tasks, activities and strategies (Kruger & Summers, 1993) were very much dominated by *Primary Investigations* curriculum materials and hence Anna had little opportunity to exhibit practices that could be described as child initiated. What was evident was some degree of control gradually given to students to engage in reflective dialogue with the teacher (Lesson 6) and the willingness to provide interesting and appropriate representations (Lesson 6). There was no change in her willingness to share control of the design, management and evaluation of their learning. The notion that scientific knowledge is tentative is not explicitly expressed but in her discourse with the class, she often refers to her own tentative knowledge of science. Her view of the dynamic nature of the growth of scientific knowledge is also expressed. During our observations of her teaching she referred to media reports of scientific discoveries and changing understandings of certain phenomena. This was particularly evident in discussions about weather that emerged towards the end of the series of broadcasts. Missing from her practice was the extensive use of child-child interactions and reflective practices.

## Summary and Conclusions

This research has been a case study of the impact of a series of television broadcasts, *Simply Science*, on the professional practice of a teacher being introduced to a new curriculum programme—*Primary Investigations*. The broadcasts were limited in scope and directed at two audiences. Firstly there were two transmissions to teachers which addressed the philosophy and structure of the curriculum package. Both transmissions appeared directed and strategic in that they provided a superficial overview of the structure of the *Primary Investigations* but did not realistically achieve any conceptual development. Little more would have been expected from such limited opportunity. Six transmissions for Grade 3/4 children were broadcast and purported to involve interactive engagement in problem solving. This feature did not appear from the data to be of any significant value. The most useful aspect of the programme was the opportunity for children to observe other children engaged in science activities and to see interesting demonstrations that were linked with real world events dramatically displayed by film.

Our primary concern was to what extent the vicarious experiences would impact on the teacher's sense of self-efficacy. Anna was an experience teacher and already quite interested in science which was, with mathematics, her preferred teaching options. She was a teacher who was quite interested in the project and keen to be involved in any activity that would enhance the learning outcomes of her children. On the other hand, she had not been involved in any inservice programmes previously with science possibly because of lack of opportunity although the local Science Teachers Association provides conferences and workshops specifically for primary teachers. In her teaching practice she probably, metaphorically saw herself more as a director, encouraging children to engage in learning, providing facilities and presenting information. Her teaching was teacher centred with most discourse occurring between teacher and student. The co-operative learning model was a new experience and its implementation was of limited success. Yet there were important positive changes in Anna's attitudes and confidence with regard to co-operative learning which were reflected in her final comments and the observations of Lesson 6. Her change in self efficacy was small and in fact slightly negative, but that may reflect apprehension about her own knowledge base and possible implications of a full implementation of the inservice that would accompany the adoption of *Primary Investigations* by the school.

This research provides insight into two aspects of professional development. Firstly, there is a substantial investment of time and money in inservice programmes, which to be successful require collaboration and co-operation of whole school communities. Given that teachers are faced with a continual barrage of change their motivation for co-operating intuitively will depend on the importance they attribute to the change and the likelihood that they are able to cope with the changes. The concept of self efficacy addresses the extent to which teachers will have these attitudes. To change self efficacy, teachers need to have experienced success, vicarious experiences, or be exposed to effective and powerful persuasive arguments. Thus, when the inservice is delivered and the support is gone, who will take responsibility for the ongoing implementation. The answer to this may rest with those teachers who have high levels of self efficacy and can motivate, support and mentor less efficacious teachers through modelling, establishing action research cells and adopting leadership roles.

Secondly, the delivery of inservice packages needs to be conducted with an awareness of issues concerning motivation to change. While it is appropriate to focus on individual packages, teaching strategies, theoretical issues underpinning the learning of science, enabling strategies also need to be developed. The critical role of inservice agents is to establish within schools reflective practices and to develop an environment conducive to change. Thus identification of key personnel with high self efficacy prior to inservice will enable a process to be set up that provides a welcome environment for the inservice. Teachers, administrators and support staff need to be convinced of the long term benefits of inservice. This research should inform the developers of the inservice programme of these issues and the potential of targeting highly self efficacious teachers as promoters of change in science education.

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